EFFECT OF LID POSITION, CORNEAL DIAMETER, CORNEAL SHAPE, AND RIGID LENS OVERALL DIAMETER ON LENS MOVEMENT AND POSITIONING

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INTRODUCTION:

The purpose of the study was to determine the normal position of the lid margins with respect to the limbus of the general population. The lid positions were then correlated to the positioning of different diameter rigid lenses.

In the fitting and design of rigid contact lenses it is important to know the characteristics, and the variation in these characteristics, that affect lens positioning and comfort. One of the most important factors is lid position with respect to the limbus and the effect of the lid forces on lens position. Very little quantitative data is available on the lid position with respect to the corneal limbus and in turn the effect of the lid position on lens positioning and movement. This information is important in designing lenses and in fitting. With such information one can better determine what lens diameters should be used to best fit the majority of the population and what increment in lens diameter is significant in changing lens performance.

METHODS:

General information such as the patient's age, spectacle refraction and previous contact lens wear were obtained from each patient. Patients who wore or had previously worn any rigid or hard type lenses were excluded from the study. Only one eye was used from each patient and was choosen on a random basis. Corneal curvatures of the patients were measured with the Autokeratometer and the shape factor from this measurement

was used as an indicator of corneal shape. In order to ensure that the data was reliable for the general population, those patients having a measured amount of corneal astigmatism greater than 2.5 diopters were excluded from the study.

For the other measurements the patients were positioned with their heads in a head rest. With the patient looking straight ahead at the center of a camera lens, the anterior segment of the eye was videotaped using a low light level CCD video camera. Following this, the lids were held open such that both the upper and lower limbus was visible. A scale was videotaped so that magnification of the system could be determined. From the above videotape the normal palpebral aperture was measured. The visible iris diameter (VID) in the vertical and horizontal meridians was also measured. The distance of the upper lid from the upper limbus and the distance of the lower lid from the lower limbus was determined from the tape. If in the normal position both of the lids cover the limbus the position of a detail on the conjuctiva, such as a prominent vessel, was determined with respect to the upper and lower limbus when the lids were held open. From the position of this vessel the location of the normal lid position with respect to the limbus was determined.

The corneal diameter was measured using a modification of the Martin-Holden procedure(1). Two line light sources, formed by fluorescent bulbs, were positioned at the 45 degree angles such that the sources were reflected from the limbus at an angle. The break in the reflected image occured at the change in curvature between the cornea and sclera. From the videotape of the above reflected images the corneal diameter was determined. This was greater than the VID.

Following the taping of the above, four different diameter lenses were placed on the subject's eye in a random order. A drop of corneal anesthetic was applied first to prevent any irritation from the lens causing a decrease in lid aperture or excessive tearing. The four lenses that were used were 9.0, 9.5. 10.0, 10.5 mm. overall diameter rigid lenses with 7.9mm optical zones, -3.00D power, and 0.12mm axial edge lifts. The 9.5 mm lens had a center thickness of 0.12 mm while the other lenses were 0.16 mm thick. The lenses were fitted on K or in the case of corneal toricity they were fit on the average K. The position and movement of the lens was videotaped for ten consecutive blinks. The position of the lens just prior to the next blink was measured. Also the amount of lens movement occuring during each of the ten blinks was measured.

DATA ANALYSIS:

All of the data was entered into a database and correlations were done between lid positions, VID, actual diameter, corneal topography and the lens position and movement.

RESULTS:

For thirty-seven subjects ocular parameters were measured and averaged. The mean age was 24.57 years with a range of 20 to 60 years of age. Of those tested the average sphere refraction was -1.32D. The mean cylinder power was -0.534D.

As measured with the Autokeratometer the average horizontal K-reading was 43.95 and the average vertical K was 44.50. The shape factor averaged 0.174 as measured by the same instrument. The apex of the cornea varied in horizontal placement from 1.33mm nasal to 4.66mm temporal with a mean position of 0.314mm nasal. The vertical placement averaged 0.86mm below center, varying from 0.20mm above center to 8.27mm below center.

As measured with the videotape, the mean vertical visible iris diameter was 10.99mm. While the mean horizontal visible iris diameter was 11.78mm. Using the Martin-Holden procedure the mean actual corneal diameter was found to be 12.716mm.

The evaluation of the lids of the thirty-seven subjects yielded a mean upper lid position of 1.103mm of corneal coverage with ranges varying from 1.10mm of superior scleral exposure to 2.50mm of corneal coverage. On examination of the lower lid position the mean was found to be 0.0405mm of inferior scleral exposure. (See Chart 1)

For forteen of the above thirty-seven subjects lenses were placed on the eye and measurements were taken. All four diameter lenses showed temporal displacement while on the eye. The 9.0mm lens averaged a temporal displacement of 0.763mm, the 9.5mm lens 0.82mm, the 10.0mm lens 0.60mm and the 10.5mm lens 0.298mm. (See figure A)

Upon examination of vertical positioning, three out of the four diameter lenses averaged downward decentration. The mean downward displacement of the 9.0mm lens was 0.516mm, 0.259mm for the 10.0mm lens, and 0.285mm for the 10.5mm lens. The 9.5mm lens, however, had a mean decentration of 0.197mm upward. (See figure B)

The amount of lens movement was also studied. The 9.0mm lens exhibited a mean amount of movement of 0.815mm, the 9.5mm lens 1.167mm, the 10.0mm lens 1.081mm and the 10.5mm lens showed an average of 1.303mm of movement. (See figure C)

CONCLUSIONS AND DISCUSSION:

The mean position for the upper lid was determined to be 1.103mm below the superior corneal limbus. This parameter appeared to vary widely among the subjects evaluated. The lower lid was found to have an average position of 0.0405mm below the inferior corneal limbus.

The mean values for the ocular parameters studied are found in Chart 1 above. It is evident by the standard deviations that most of these parameters show a relatively wide variation as measured from subject to subject.

Upon data analysis no correlations could be found between the ocular parameters measured and lens movement and positioning.

When the 9.5mm lens is excluded from the evaluation, lens movement and positioning versus lens diameter seems to follow a rather linear relationship as can be visualized on figures A-C. It appears here that as the lens diameter is increased from 9.0 to 10.5mm the amount of horizontal and vertical displacement decreases in a relatively linear fashion and the amount of lens movement increases, also in a relatively linear fashion. This brings up an interesting point. The 9.5mm lens does not fit the data. This leads one to wonder if this is mere coincidence or if is it due to the fact that the 9.5mm lens was 0.04mm thinner than the other lenses used. It would be interesting, as a follow-up study,to examine the effect of lens thickness on lens position and movement.

References:
1. Martin, D.K. and B.A. Holden, A New Method for Measuring Diameter of the In Vivo Human Cornea, Am. J. Optom. 59(5):436-441,1982.

CHART A: 37 patients

Parameters:	Mean:	Standard Deviation:
Age In Years	4.57	+/- 6.49
Spherical Refraction	-1.32	2.56
Cylinder Refraction	-0.534	0.57
Horizontal K	43.95	1.24
Vertical K	44.50	1.36
*Shape Factor	0.174	0.095
**Apex Position		
horizontal	0.314	0.936
vertical	-0.86	0.76
Horizontal VID	11.78	0.456
Vertical VID	10.99	0.922
Actual Corneal Diameter	12.716	0.602
***Upper Lid Position	1.103	0.726
****Lower Lid Position	-0.0405	0.510

*The shape factor is related to the eccentricity and is an indication of corneal shape. Since the Auto Keratometer measurements are made along a horizontal line, the shape factor refers to the shape of the cornea in a horizontal cross-section only. A zero shape factor indicates the cornea has zero flattening out from the apex. A cornea with a zero shape factor has a circular cross-section.

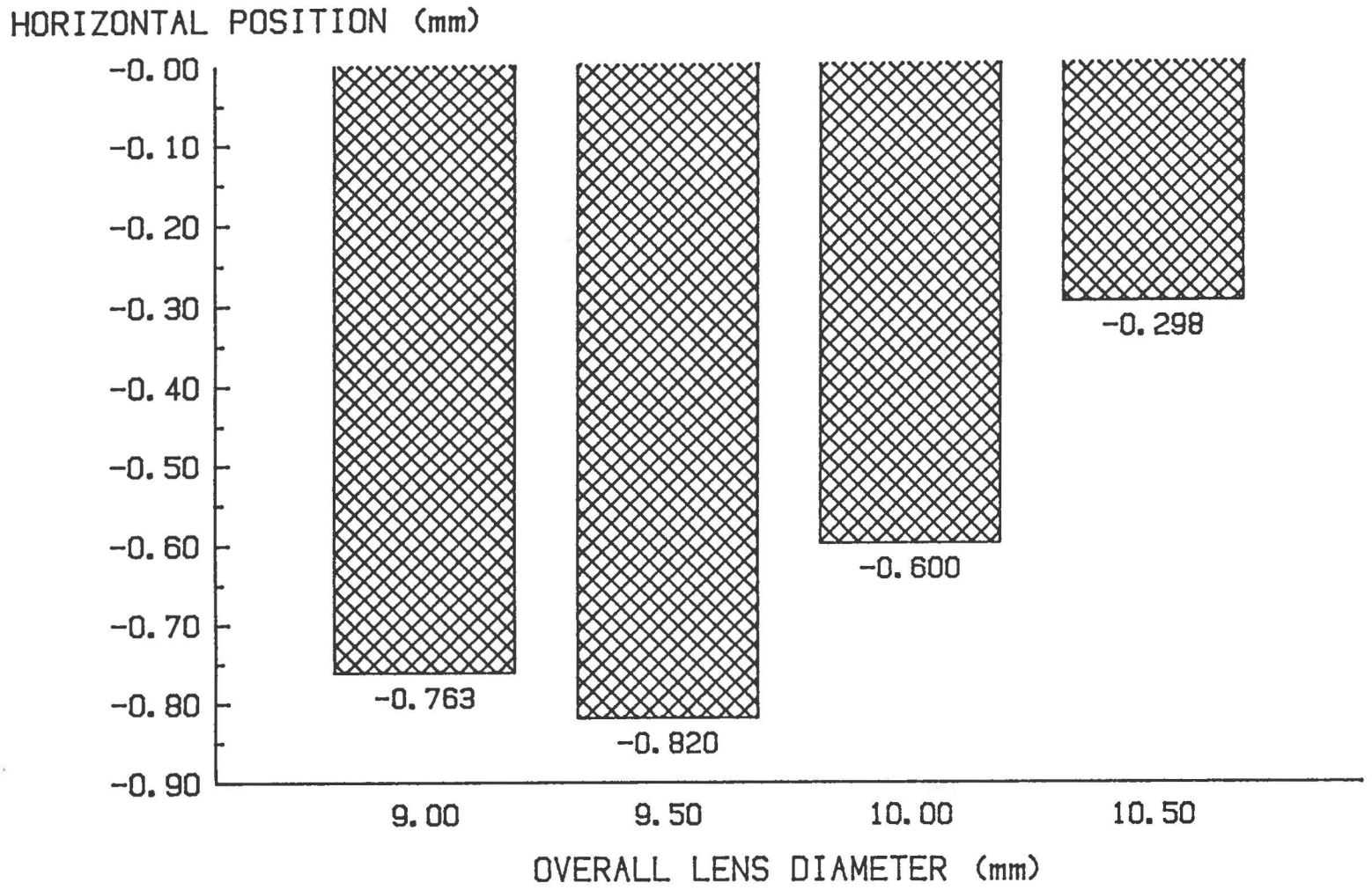
**A positive horizontal apex position indicates nasal displacement. A positive vertical apex position indicates superior displacement.

***Positive values indicate that the superior limbus is covered by the upper lid.

****Positive values indicate that the inferior limbus is covered by the lower lid.

FIGURE A:

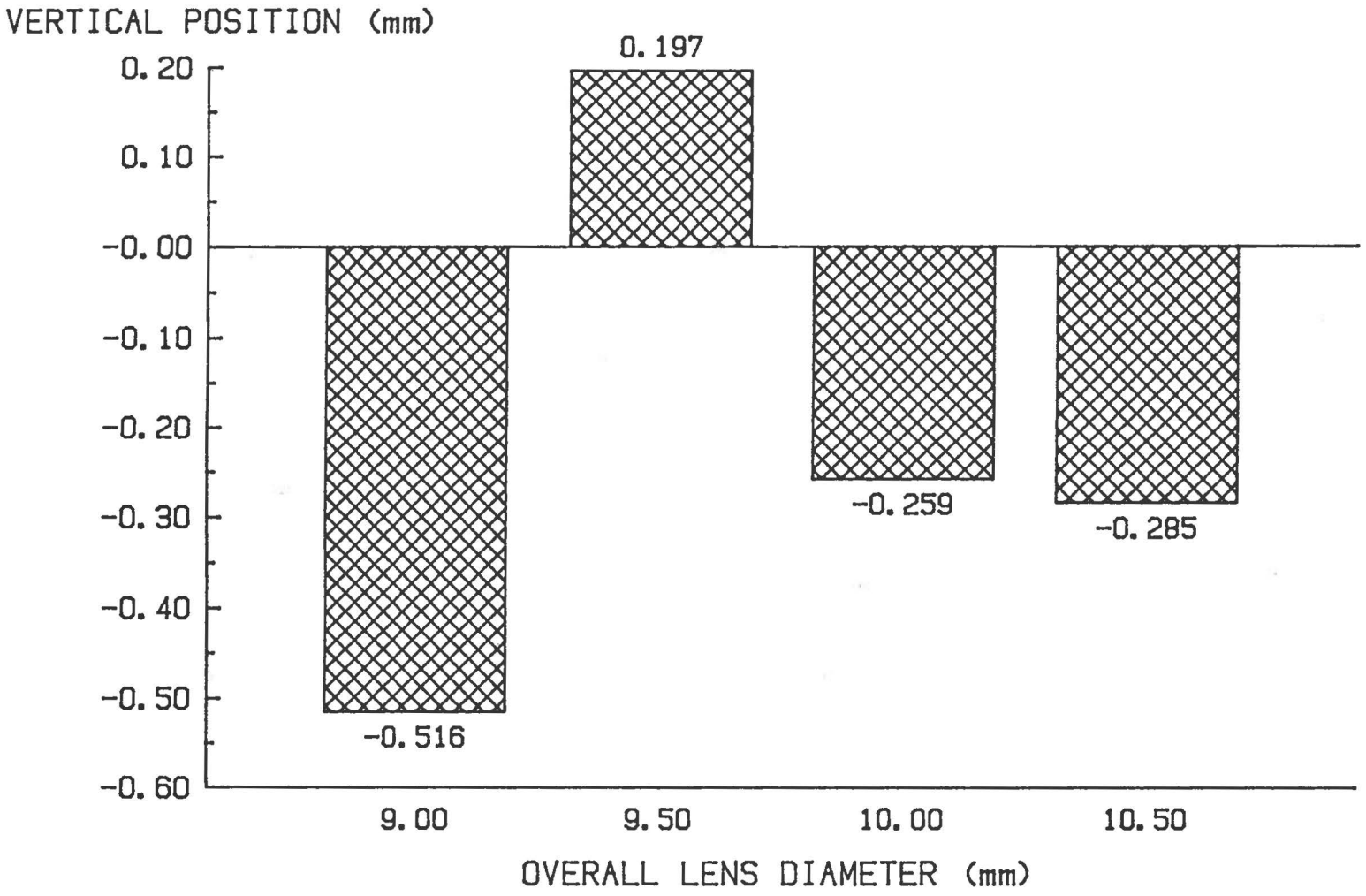
HORIZONTAL LENS POSITION BY LENS DIAMETER



14 Patients
- values=temporal displacement

FIGURE B:

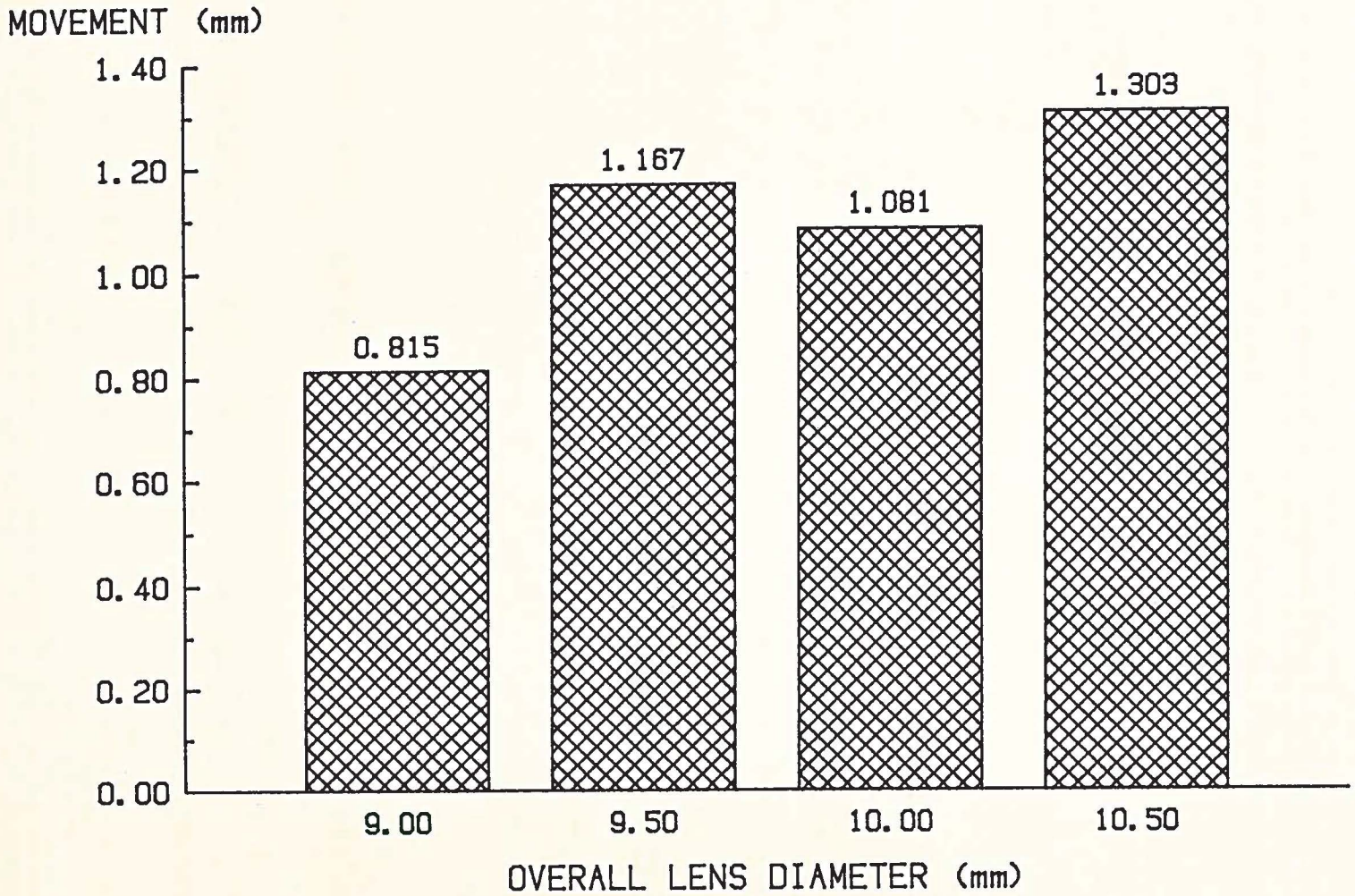
VERTICAL LENS POSITION BY LENS DIAMETER



14 patients
- values=decentered down

FIGURE C:

LENS MOVEMENT BY LENS DIAMETER



14 patients